

# **INDOOR AIR QUALITY ASSESSMENT**

**Plymouth South Middle School  
488 Long Pond Road  
Plymouth, Massachusetts**



Prepared by:  
Massachusetts Department of Public Health  
Bureau of Environmental Health Assessment  
Emergency Response/Indoor Air Quality Program  
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## **Background/Introduction**

At the request of Arthur Montrond, Supervisor of Buildings and Grounds for the Plymouth School Department (PSD), the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality concerns at the South Middle School (SMS) in Plymouth, Massachusetts. The request was prompted by concerns about mold as a result of excessively humid weather during the first three weeks of August 2003.

On October 31, 2003, a visit to conduct an assessment and examine remediation efforts to water damaged/mold colonized materials of the school was made by Cory Holmes, an Environmental Analyst in BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) program. Water damaged materials are discussed further in the Microbial/Moisture Concerns section of this report. BEHA staff had previously conducted an investigation and issued a letter regarding water penetration in January 2002 (MDPH, 2002).

## **PSD Actions on MDPH Recommendations**

As mentioned, BEHA staff had previously visited the building and issued a report that made recommendations to improve indoor air quality and remediate water penetration issues. A summary of actions taken on previous recommendations is included as Appendix A of this assessment.

## **Methods**

BEHA staff performed, visual inspection of building materials for water damage and/or microbial growth. Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

## **Results**

This school houses approximately 950 students in grades 5-8, with a staff of approximately 200. Tests were taken during normal operations at the school and results appear in Table 1.

## **Discussion**

### **Ventilation**

It can be seen from Table 1 that carbon dioxide levels were below 800 parts per million of air (ppm) in ten of seventeen areas surveyed, indicating adequate ventilation in the majority of the areas of the classroom wing. It is important to note, however, that the mechanical ventilation system was not operable at the time of the assessment, due to building envelope repairs. As indicated in Table 1, several classrooms had open windows during the assessment. In addition, drafts were entering classrooms from spaces around ventilation ductwork to be installed (see below). Open windows and drafts through breaches in the building envelope can greatly reduce carbon dioxide levels. In contrast, the majority of classrooms with elevated carbon dioxide had windows closed.

Fresh air in classrooms is supplied by a unit ventilator (univent) system (Picture 1). Univents draw air from outdoors through a fresh air intake located on the exterior

walls of the building and return air through an air intake located at the base of each unit ([Figure 1](#)). Fresh and return air are mixed, filtered, heated or cooled and provided to classrooms through a fresh air diffuser located in the top of the unit. Adjustable louvers control the ratio of outside to recirculated air. All univents in the classroom wing were disconnected to aid building repairs to prevent water penetration (Picture 1/Appendix A). The only means to introduce fresh air into classrooms at the time of the assessment was opening windows.

The mechanical exhaust ventilation system consists of wall-mounted exhaust vents connected to exhaust fans on the roof (Picture 2). This system was operating during the assessment facilitating the draw of fresh air into classrooms. The operation of the exhaust system depressurizes the classroom, which draws, outside air through open windows. BEHA staff recommended that classroom occupants open windows (to be used in conjunction with mechanical exhaust vents) to create cross-ventilation until univents were installed.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. Balancing of these systems should be considered once univents are installed and fully operational. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have

openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, see [Appendix B](#).

Temperature measurements ranged from 71° F to 75° F, which were within the BEHA recommended comfort range the day of the assessment. The BEHA recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide

for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. It is also difficult to control temperature and maintain comfort without ventilation equipment operating due to on-going repairs. To help maintain comfortable temperature the PSD purchased and installed space heaters in each classroom after consultation with the Plymouth Fire Department.

The relative humidity measured in the building ranged from 50 to 61 percent, which was very close to the BEHA recommended comfort range. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

### **Microbial/Moisture Concerns**

In the experience of BEHA staff, excessively humid weather can provide enough airborne water vapor to create adequate conditions for mold growth in buildings. Relative humidity in excess of 70 percent can provide an environment for mold and fungal growth (ASHRAE, 1989). Mold growth was reported in classrooms on all three floors of the classroom wing. In general, materials that are prone to mold growth can become colonized when moistened for more than 24-48 hours. Since hot, humid weather persisted in Massachusetts for more than 14 days during the month of August (The Weather Underground, 2003), materials in a large number of schools and buildings were

moistened for an extended period of time. Both the water penetration problems through exterior walls (Appendix A), and the excessive relative humidity during the first three weeks of August 2003 created mold growth conditions on interior building components. In addition, classroom univents are equipped with cooling coils to remove water vapor and reduce humidity. Since these units were disconnected to repair flashing around ductwork, the means to remove excess moisture/humidity was unavailable.

Materials in the building that were reportedly colonized with mold included both fixed building components (e.g., gypsum wallboard, pipe insulation) and movable materials (e.g., books, desks and tables). At the time of the assessment all mold-contaminated materials were removed (Pictures 3 & 4). Microbial remediation and cleaning activities were conducted by LVI Environmental Services, Inc. under the direction of Covino Environmental Associates, Inc who submitted a Microbial Remediation Work Plan (Covino, 2003) to the PSD. The first floor was unoccupied during the assessment due to renovation work being conducted to install new building components; work was completed on the second and third floors, which were occupied during the assessment.

The US Environmental Protection Agency and the American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials be dried with fans and heating within 24-48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur. Water-damaged porous materials cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy porous materials is not recommended.

## **Other Concerns**

Several other conditions that can affect indoor air quality were noted during the assessment. A number of classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain volatile organic compounds (VOCs), such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Finally, in an effort to reduce noise from sliding chairs, tennis balls had been sliced open and placed on chair legs (Picture 5). Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and lead to off gassing of VOCs. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g., spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as [Appendix C](#) (NIOSH, 1998).

## **Conclusions/Recommendations**

In order to prevent future water damage to the school building components the PSD is acting to both remove colonized materials and repair the sources of water penetration through the building envelope. This project is consistent with recommendations made previously by BEHA staff as well as a variety of mold remediation guidelines.

In view of the findings at the time of the current visit, the following recommendations are made:

1. Continue with plans to repair flashing around univents and make repairs to the building envelope to prevent further water penetration.
2. Once univents are installed the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy independent of classroom thermostat control. Consider having ventilation systems re-balanced by an HVAC engineering firm.
3. Examine each univent for function. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room. Operate univents while classrooms are occupied. To increase airflow, set univent controls to “high”.
4. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a HEPA filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
5. Clean dry erase board trays regularly to avoid the build-up of particulates.
6. In order to maintain a good indoor air quality environment on the building, consideration should be given to adopting the US EPA document, “Tools for Schools”. This document can be downloaded from the Internet at <http://www.epa.gov/iaq/schools/index.html>.

7. For further building-wide evaluations and advice on maintaining public buildings, see the resource manual and other related indoor air quality documents located on the MDPH's website at <http://www.state.ma.us/dph/beh/iaq/iaqhome.htm>.

## References

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- US EPA. 2001. Mold Remediation in Schools and Commercial Buildings. US Environmental Protection Agency, Office of Air and Radiation, Indoor Environments Division, Washington, DC. EPA 402-K-01-001. March 2001.

**Picture 1**



**Disconnected Univent in Classroom**

**Picture 2**



**Classroom Return Vent**

**Picture 3**



**Pipe Insulation and Ceiling Tiles Removed in First Floor Classroom**

**Picture 4**



**Wall Materials, Ceiling Tiles and Pipe Insulation Removed in First Floor Classroom**

**Picture 5**



**Tennis Balls on Chair Legs in Classroom**

**TABLE 1****Indoor Air Test Results – South Middle School – Plymouth, MA****October 9, 2003**

Location	Carbon Dioxide *ppm	Temp °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Outdoors (Background)	390	72	63					Atmospheric Conditions: warm, scattered clouds, NW winds 5-10 mph
First Floor Classrooms (unoccupied)								Pipe insulation/wallboard removed, Univents disconnected-flashing reinstalled, pipes along exterior wall need to be re-routed
202	713	72	58	2	Y	Y	Y	Univent disconnected, door open, 54 occupants gone 5 min
203	998	71	61	21	Y	Y	Y	Univent disconnected, door open
204	950	74	58	24	Y	Y	Y	Univent disconnected
207	864	75	55	20	Y	N	Y	Univent disconnected
209	611	73	51	1	Y	Y	Y	Univent disconnected, window open
213	616	72	52	8	Y	Y	Y	Univent disconnected, door open
214	850	73	55	3	Y	Y	Y	Univent disconnected

\* ppm = parts per million parts of air  
 UV = Univent

**Comfort Guidelines**

Carbon Dioxide - < 600 ppm = preferred  
 600 - 800 ppm = acceptable  
 > 800 ppm = indicative of ventilation problems

Temperature - 70 - 78 °F

Relative Humidity - 40 - 60%

**TABLE 1****Indoor Air Test Results – South Middle School – Plymouth, MA****October 9, 2003**

Location	Carbon Dioxide *ppm	Temp °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
216	621	72	53	0	Y	Y	Y	Univent disconnected
219	614	73	53	19	Y	Y	Y	Univent disconnected, window open
218	708	72	54	21	Y	Y	Y	Univent disconnected
302	640	74	54	5	Y	Y	Y	Univent disconnected, window open
305	848	75	54	25	Y	Y	Y	Univent disconnected, window open, door open
306	846	75	53	21	Y	Y	Y	Univent disconnected, 2 CT, door open, window open
312	682	74	50	27	Y	Y	Y	Univent disconnected, door open, window open, tennis balls-chairs
315	826	74	52	6	Y	Y	Y	Univent disconnected
317	732	74	51	0	Y	Y	Y	Univent disconnected
318	700	74	50	7	Y	Y	Y	Univent disconnected, dry erase board particulate, door open

\* ppm = parts per million parts of air

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Temperature - 70 - 78 °F

Relative Humidity - 40 - 60%

# **Appendix A**

## **Plymouth School Department Actions on MDPH Recommendations**

The following is a status report of actions taken on MDPH recommendations (**in bold**) provided in the January 2002 BEHA report. The summary is based on reports from Plymouth School Department (PSD) Officials, school maintenance staff, and documents, as well as photographs and observations made by MDPH/BEHA staff.

Actions on Recommendations:

- 1. Remove mold contaminated porous building materials (e.g., ceiling tiles, GW). This measure will remove actively growing mold colonies that may be present. This work should be conducted at a time when occupants are not present in the area. Contain the area where contaminated materials are removed to prevent the spread of dust and mold spores. Once work is completed, ensure that the area is thoroughly cleaned and disinfected with an appropriate antimicrobial. Renovation generated dust and particulates in carpeted areas should be vacuumed with a HEPA filtered vacuum cleaner. Replace all water damaged building materials once leaks are repaired.**

**Action Taken:** All water damaged/mold contaminated building materials were replaced and/or disinfected.

- 2. Address/implement the recommendations made in the SG&H and Wessling reports.**

**Action Taken:** In response to the above mentioned reports and extensive repairs to the building envelope were conducted and tested for integrity. These repairs included the re-sealing of all windows and complete removal and reconstruction of the building exterior.

Due to continuing water penetration issues a further investigation was conducted and found

drainage problems with the curtain wall/drainage plain as well as end dam flashing around univents duct sleeves. At the time of this assessment masons were in the process of finalizing repairs to univent end dam flashing and drainage plain issues (Pictures A1 & A2).

**3. Consider contacting the Bureau of Environmental Health 's Emergency**

**Response/Indoor Air Quality program following a period of wind driven rain to schedule follow-up moisture testing.**

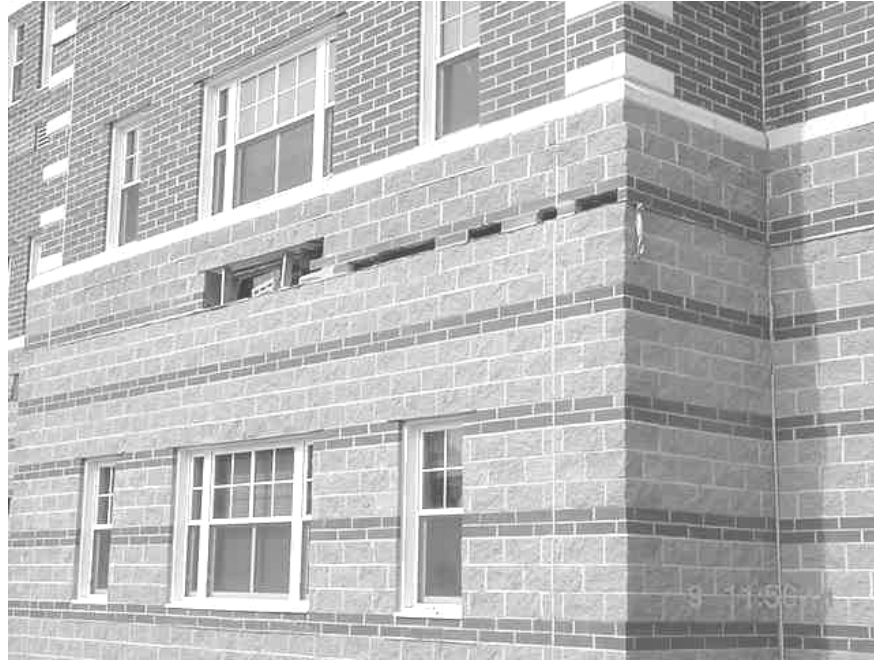
**Action Taken:** Although BEHA was not contacted to conduct further moisture testing, the water penetration issues and continued water penetration problems at the SMS were well-documented by the PSD and their consultant Covino Environmental Associates, Inc.

**Picture A1**



**Interior View of Repairs to Univent End Dam Flashing/Drainage Plain**

**Picture A2**



**Masonry Removed to Conduct Repairs to Univent End Dam Flashing/Drainage Plain**